Characterization of the Potential Yield of Clone IRCA230

S. Hav[1], S. Mak [1], C. Chhek[1] and R. Lacote[2]

[1.]CRRI, # 09, PennNouth Blvd, Boeung Kak 1, Tuol Kork, Phnom Penh, Cambodia, P.O Box: 1337
[2.] Cirad, UR 34, Tree Crop Based Systems, TA /B34, 34398 Montpellier, France

Abstract
The experiment on Yield Potential Comparison on S/2 d3 and S/2d4 Tapping Systems of Clones IRCA230 were practiced on farm research at Chup Rubber Research Station of Cambodian Rubber Research Institute (CRRI). The experimental design was the RCBD with 8 treatments and 4 replications with a total number 400 trees per replication. They were opened at the standard girth of 50 cm measured at 1m high. All the trees were opened at 1.3 m from the ground. The tapping systems were S/2 d3 7d/7 and S/2 d4 7d/7. This clonal typology is based on measurements issued from the latex diagnosis. The objective of the experiment was to investigate the yield potential comparison of the tapping system S/2 d3 7d/7 and S/2 d4 7d/7 based on frequency of ethephon stimulation. Stimulation was related to the sucrose and inorganic phosphorus contents of the latex cells. Clone IRCA 230, with higher sugar content, with high ethephon stimulations per year obtained the highest yield. The cumulative yield in gram per tree over 8 years of tapping showed frequency d3 higher yield than frequency d4. The yield of tapping frequency with stimulation 1.5% 7/y control was higher than them.

Keywords: *Hevea, clone IRCA 230, yield potential, tapping systems*

Introduction

Yield stimulation offers opportunities for reducing tapping frequency from d3 to d4 and increased land or labor productivity (Sivakumaran and Chong, 1984, Lukman 1995, Gohet, 1996, Thanh, 1996 and 1998, Nugawela et al., 2000, Vijayakumar et al., 2001, Obouayeba et al., 2012, Lacote et al. 2014). In Cambodia the S/2 d3 7d/7 tapping system is used in routine. Estates, as well as, smallholders do not use any more intense tapping frequency like d2 Cambodian Rubber Research Institute (CRRI) is developing research on tapping system to estimate the influence of tapping intensity and stimulation on yield with given tapping frequency. The objective of the experiment was to investigate the yield potential for tapping system S/2 d3 7d/7 and S/2 d4 7d/7 of the clone IRCA 230, during 8 years. Intensity of stimulation was modulated according to clonal characteristics (Serres et al., 1988, Jacob et al., 1989, Gohet et al., 1995 and 1996, Lacote R et al., 2010, Lacote et al., 2014).

Materials and Methods

Experimental site

This study was carried out in the CRRI research station in Thbong Khmom province for comparing and identifying optimum stimulation frequencies under d3 and d4 tapping frequencies of half spiral cuts in panel BO-1 and B0-2 of clone IRCA230.

The area are characterized a monsoon rainfall regime, a marked by a 6 months rainy season (May to November) and a 6 months dry season (December to April). The total rainfall for both sites was highest in the month of July to September and lowest in the month of December to January.

Planting materials

Recently, clone IRCA230 was widely planted clone in Cambodia like GT1. This clone was studied in the CRRI research station in Thbong Khmom province, Cambodia. They were opened at the standard girth of the trunk at 50 cm to take measurement at 1 m high. All the trees were opened at 1.3 m from the ground. Clone IRCA230 known as a medium metabolism

clone that react to the stimulation and yield (Lacote et al., 2010). This clone displays the main types in the clonal typology of the lactiferous metabolism established by CIRAD (Jacob et al., 1985; Serres et al., 1988, Jacob et al., 1989 and Gohet et al., 2003). This clonal typology is based on measurements issued from the latex diagnosis (Jacob et al., 1998 and 1995).

Experimental designed

The experimental area was around 4 ha per trial. Trees were spaced at 6 m x 3 m (555 trees per ha). The experimental design was a randomized complete block designed with 4 treatments and 4 replications. Age of rubber trees of each clone, at the time of the beginning of the trial was 6 years old. The trees of equal size were selected. We applied one gram of containing ethephon with 1.5%, 2.5% and 3.3% active ingredient on the panel application of stimulation. The trees had been planted in 1997 and opened in March, 2003. Tapping was on panel BO-1 and BO-2. The different treatments are as follows.

Table1: The details of each treatment

Treatments	The detailed content of treatments
T0	S/2 d3 7d/7 Nil stim
T1	S/2 d3 7d/7 ET 1.5% Pa 7/y (control)
T2	S/2 d3 7d/7 ET 2.5% Pa 6/y
T3	S/2 d3 7d/7 ET 2.5% Pa 8/y
T4	S/2 d4 7d/7 ET 2.5% Pa 4/y
T5	S/2 d4 7d/7 ET 2.5% Pa 8/y
T6	S/2 d4 7d/7 ET 2.5% Pa 12/y
T7	S/2 d4 7d/7 ET 3.3% Pa 4/y

Concentration of ethephon applied for experiment were 1.5 %(treatment widely used in most of the rubber estates in Cambodia), 1.5%, 2.5% and 3.3% with water diluted (5% stock of commercial ethephon). Panel application was found to be most effective and economic (Rajagopal *et all.*2000).

Measurements and data processing

To record yield, daily fresh latex of each replication per treatment was weighed. Cup lumps were collected then weighed the day after. A cumulated yield was calculated every month. Latex yield was expressed in grams per tree per tapping and gram per tree. Dry rubber content of latex from each block was determined gravimetrically at every week. Dry rubber content of cup lumps was measured for a bulk in each treatment in order to convert yields in grams of dry rubber per tree. The girth of the trees was measured at 1.70 m above ground level. The TPD of the tree were count in December every one time per year. Statistical analysis of latex yields, girth increments latex diagnosis were carried out by using the SPSS statistical software. Significant differences test, with 5% sig, were used.

Results

1. **Yield**

- Mean dry rubber yield gram per tree (g/t) over 8 years of tapping

For panel BO-1, the yield was the highest with ethephon treatments with d3 tapping frequency whatever the frequency of stimulation (Table 2). The d4 frequency produced always less than the d3 frequency. For d3 frequency, stimulation induced a significant higher yield in g/t in comparison to the non-stimulated treatment (T0). But there was no significant difference between stimulated treatments. For the d4 frequency, table 2 showed higher stimulation frequency higher the yield. The lower stimulation frequency with 2.5% 4/y and

3.3% 4/y of *a.i.* showed lowest yield.. For panel BO-2, in d3 frequency, there was significant difference between stimulated treatments. . Tapping frequency d3 showed highest yield with treatments with stimulation 1.5% 7/y and 2.5% 6/y. The d4 frequency showed significant difference between the frequencies of stimulation. The stimulation at 4/y with 2.5% *a.i.* and 4/y 3.3% of *a.i.* showed lowest yield. Stimulations at 2.5% 8/y and 2.5% 12/y showed highest yield. Logically, more stimulation is needed to compensate the lower tapping frequency.

- Mean dry rubber yield gram per tree per tapping (g/t/t) over 8 years of tapping

For panel BO-1, the yield in g/t/t was the highest with the tapping frequency d4 with the frequency of stimulation 2.5% 12/y (47.3 g/t/t). The tapping d3 produced always less than the d4 frequency. For d3 frequency, stimulation induced a significant higher yield in g/t/t in comparison to the non-stimulated treatment. On panel BO-2 the yield in d4 frequency, still increased when stimulation frequencies increased (Table 3).

The cumulative yield over 8 years of tapping showed that frequency d3 produced higher yield than frequency d4 (Table 4). Only with the highest stimulation frequency (12/y) the yield of frequency d4 was similar than yield with frequency d3. The yield of tapping frequency with stimulation 1.5% 7/y control was the highest in the trial (Table 4).
Frequency d4 always showed higher yield in g/t/t over 8 years than frequency d3. The yield d4 with stimulation 2.5% 8/y and 2.5% 12/y were the highest (Table 4).

2. Growth

Over 8 years, all treatments of tapping frequency d3 showed higher growth than tapping frequency d4 with a significant difference. The total girth increment over 8 years, of the only treatment T2 of tapping frequency d3 was higher than the other ones (Table 5).The lowest girth rate was shown with the highest yielding g/t/t treatment in d4, T6: higher the g/t/t, lower the girth increment.

3. Tapping panel dryness (TPD)

TPD of all treatments was observed in December 2013 (Table 4). The results showed that the total dryness varied from 4.7 to 10.7 %. Treatment with ethephon 2.5% 8/y of d3 showed the highest presence of dry trees (10.7%). For each tapping frequency, higher the stimulation rate, higher the presence of dry trees.

4. The latex diagnosis parameter (LD)

The latex diagnosis of all treatments measured in 2014 was shown in Table 6. Sucrose content of frequency d3 with no stimulation was the highest. Both stimulation frequencies (with concentration in ethephon) showed a tendency to decrease the sucrose content. Inorganic phosphorus content (Pi) did not show any changes between treatments There is a tendency to lower Pi content with treatments T0 and T7 respectively without stimulation in d3 frequency and with 12 stimulation per year in d4 frequency. Thiols contents (R-SH) were significantly higher in d3 frequency without stimulation and with stimulation at only 1.5% than the other treatments.

Table 2: Cumulated yield in g/t of comparison d3 and d4 of clone IRCA230 over 8 years of tapping

Treatments	Panel	Years of Tapping				Cumulate
		1	2	3	4	
T0: S/2 d3 Nil stim	BO-1	2366 bc	3496 cde	3738 ab	3343 b	12943 b
T1: S/2 d3 ET 1.5% 7/y (cont)	BO-1	2893 ab	4117 ab	4170 a	4193 a	15373 a
T2: S/2 d3 ET 2.5% 6/y	BO-1	2777 ab	3991 abc	4020 ab	4088 a	14876 a
T3: S/2 d3 ET 2.5% 8/y	BO-1	3179 a	4290 a	4142 a	4445 a	16055 a
T4: S/2 d4 ET 2.5% 4/y	BO-1	2022 c	3256 e	2624 c	2581 c	10482 c
T5: S/2 d4 ET 2.5% 8/y	BO-1	2416 bc	3691 bcde	3263 bc	3149 b	12519 b
T6: S/2 d4 ET 2.5% 12/y	BO-1	2601 c	3949 abcd	3301 bc	3208 b	13059 b
T7: S/2 d4 ET 3.3% 4/y	BO-1	1875 c	3457 de	2630 c	2598 c	10560 c

Treatments	Panel	Years of Tapping				Cumulate
		5	6	7	8	
T0: S/2 d3 Nil stim	BO-2	2724 de	3752 d	3347 c	2147 c	11971 c
T1: S/2 d3 ET 1.5% 7/y (cont)	BO-2	3035 bc	4985 a	4456 a	2647 c	15060 a
T2: S/2 d3 ET 2.5% 6/y	BO-2	2840 cde	4742 ab	4494 a	3075 abc	15152 a
T3: S/2 d3 ET 2.5% 8/y	BO-2	2867 cd	4541 bc	4000 ab	1749 c	13158 b
T4: S/2 d4 ET 2.5% 4/y	BO-2	2629 e	2730 f	3269 c	3066 abc	11693 c
T5: S/2 d4 ET 2.5% 8/y	BO-2	3219 ab	3720 d	4301 a	3822 a	15063 a
T6: S/2 d4 ET 2.5% 12/y	BO-2	3345 a	4206 c	4288 a	3560 ab	15399 a
T7: S/2 d4 ET 3.3% 4/y	BO-2	2745 de	3342 e	3710 bc	3552 ab	13548 b

a, b, c, d, e: Values followed by the same letters are not significantly different (P> 0.05)

Table 3: Dry rubber yield in g/t/t of comparison d3 and d4 of clone IRCA 230 over 8 years of tapping

Treatments	Panel	Years of Tappping				Mean
		1	2	3	4	
T0: S/2 d3 Nil stim	BO-1	26.0 c	39.3 d	40.2 a	36.7 c	35.6 d
T1: S/2 d3 ET 1.5% 7/y (control)	BO-1	31.0 bc	45.8 cd	45.3 a	44.6 abc	41.7 abcd
T2: S/2 d3 ET 2.5% 6/y	BO-1	30.5 bc	44.8 cd	43.2 a	44.9 abc	40.8 bcd
T3: S/2 d3 ET 2.5% 8/y	BO-1	34.9 ab	48.2 bc	44.5 a	48.8 a	44.1 abc
T4: S/2 d4 ET 2.5% 4/y	BO-1	30.6 bc	47.9 bc	35.5 a	37.9 bc	38.0 cd
T5: S/2 d4 ET 2.5% 8/y	BO-1	36.6 ab	54.3 ab	44.1 a	46.3 ab	45.3 ab
T6: S/2 d4 ET 2.5% 12/y	BO-1	39.4 a	58.1 a	44.6 a	47.2 a	47.3 a
T7: S/2 d4 ET 3.3% 4/y	BO-1	28.4 bc	50.9 bc	35.6 a	38.2 bc	38.3 cd

Treatments	Panel	Years of Tappping				Mean
		5	6	7	8	
T0: S/2 d3 Nil stim	BO-2	26.0 c	37.5 f	31.9 d	27.6 c	30.7 c
T1: S/2 d3 ET 1.5% 7/y (control)	BO-2	27.3 c	49.9 cd	41.7 c	39.1 b	39.5 b
T2: S/2 d3 ET 2.5% 6/y	BO-2	27.0 c	47.4 de	42.8 c	39.3 b	39.2 b
T3: S/2 d3 ET 2.5% 8/y	BO-2	27.3 c	45.4 e	38.1 c	44.9 ab	41.6 b
T4: S/2 d4 ET 2.5% 4/y	BO-2	32.5 b	44.0 e	42.5 c	40.4 ab	39.8 b
T5: S/2 d4 ET 2.5% 8/y	BO-2	39.7 a	60.0 b	55.9 a	50.3 a	51.5 a
T6: S/2 d4 ET 2.5% 12/y	BO-2	41.3 a	67.9 a	55.7 a	46.8 ab	52.9 a
T7: S/2 d4 ET 3.3% 4/y	BO-2	33.9 b	53.9 c	48.2 b	46.7 ab	44.2 b

a, b, c, d, e: Values followed by the same letters are not significantly different (P> 0.05)

Table: 4 Mean yield in g/t/t and cumulated yield in g/t over 8 years of tapping

Treatments	Mean in g/t/t	%T1	Cumulated in g/t	%T1
T0: S/2 d3 Nil stim	33.1 d	82	24914 d	82
T1: S/2 d3 ET 1.5% 7/y (control)	40.6 bc	100	30497 a	100
T2: S/2 d3 ET 2.5% 6/y	40.0 bc	99	30027 ab	98
T3: S/2 d3 ET 2.5% 8/y	41.1 bc	101	29213 abc	96
T4: S/2 d4 ET 2.5% 4/y	38.9 c	96	22175 e	73
T5: S/2 d4 ET 2.5% 8/y	48.4 a	119	27581 c	90
T6: S/2 d4 ET 2.5% 12/y	50.1 a	123	28458 bc	93
T7: S/2 d4 ET 3.3% 4/y	42.3 b	104	24109 d	79
a, b, c, : Values followed by the same letters are not significantly different (P> 0.05)				

Table 5: Girth and try tree in year 8th and total increment over 8 years of tapping system in d3 and d4

Treatments	Girth in year 8th (cm)	Total increment over 8 years (cm)	%TPD
T0: S/2 d3 Nil stim	62.8 a	9.1 ab	4.7
T1: S/2 d3 ET 1.5% 7/y	61.2 a	8.4 abc	5.3
T2: S/2 d3 ET 2.5% 6/y	61.9 a	9.7 a	8.7
T3: S/2 d3 ET 2.5% 8/y	61.1 a	8.8 abc	10.7
T4: S/2 d4 ET 2.5% 4/y	58.6 b	7.2 bc	5.0
T5: S/2 d4 ET 2.5% 8/y	58.7 b	7.3 bc	7.5
T6: S/2 d4 ET 2.5% 12/y	58.6 b	7.0 c	8.1
T7: S/2 d4 ET 3.3% 4/y	58.5 b	7.8 bc	7.2
a, b, c, : Values followed by the same letters are not significantly different (P> 0.05)			

Table 6: Sucrose content (SUC), Inorganic Phosphorus content (Pi) and Thiols content (R-SH) over 8th years of tapping systems d3 and d4

Treatments	Suc(mM)	Pi(mM)	R-SH(mM)
T0: S/2 d3 Nil stim	7.70 a	29.33 a	0.19 ab
T1: S/2 d3 ET 1.5% 7/y	4.20 b	32.83 a	0.22 a
T2: S/2 d3 ET 2.5% 6/y	5.50 ab	31.14 a	0.16 b
T3: S/2 d3 ET 2.5% 8/y	6.92 ab	33.98 a	0.15 b
T4: S/2 d4 ET 2.5% 4/y	4.52 b	30.53 a	0.15 b
T5: S/2 d4 ET 2.5% 8/y	6.54 ab	32.01 a	0.18 b
T6: S/2 d4 ET 2.5% 12/y	4.14 b	27.57 a	0.15 b
T7: S/2 d4 ET 3.3% 4/y	4.99 ab	29.33 a	0.15 b
a, b, c, : Values followed by the same letters are not significantly different (P> 0.05)			

DISCUSSION - CONCLUSION

As a matter of fact, increase of stimulation intensity and frequency resulted in an increased yield according to clonal typology (Gohet at al., 1996, Gohet et al. 2003). Conversely IRCA 230 seems to be responsive clone to stimulation. Background physiological (Jacob et al., 1989) knowledge laid the principle of the clonal typology can be validated in Cambodia throughout such yield potential studies. In that kind of trial stimulation systems has been adapted as well as possible to the clonal characteristics. Some clones are absolutely in need to be stimulated more intensively to express their yield potential like clone IRCA230 especially tapping frequency d4 (Lacote et al., 2010). For some others it is not necessary to intensify ethephon stimulation. The clones are well characterized by their metabolic activity as

demonstrated in the clonal typology of latex functioning (Jacob et al., 1989). Without stimulation, clone IRCA 230 produced high latex yields with high latex inorganic phosphorus content and low or medium latex sucrose content (Lacote et al., 2010).
On panel BO-1, the yield was the highest with ethephon treatments with d3 tapping frequency whatever the frequency of stimulation. The d4 frequency produced always less than the d3 frequency. On panel BO-2 the d3 and d4 frequencies showed significant difference between the frequencies of stimulation. Tapping frequency d4 showed highest yield with stimulation 2.5% 8/y and 2.5% 12/y. logically, more stimulation are needed to compensate the lower tapping frequency. But the reduction of the stimulation frequency to 4 per year (4/y) while increasing the *a.i.* to 3.3% (132 mg ethephon) did not lead to higher yield. On the contrary, in d3 frequency, increasing the stimulation frequency to 7 per year while decreasing the *a.i.* to 1.5% (105 mg ethephon) induced a good yield as one the highest of the trial. This was observed on panel BO-1 too. For panel BO-2, the yields were higher than for panel BO-1 with the frequency d4 only. In d3 frequency, there was significant difference between stimulated treatments. At the end, the d3 frequency induced a higher yield after 8 years of tapping, according to the effect of the tapping frequency with a higher number of tapping.
There was an impact on the sucrose content in latex cells as higher the yield - lower the sucrose content, especially with the d3 frequency with stimulation at 1.5% of *a.i.* 7 times per year, and with the highest yield treatment in d4 frequency with 12 stimulations per year at 2.5%. This was already shown by Gohet et al., 1996, and 2003, Lacote et al., 2010 as a result of the effect of the latex harvesting intensity and the sucrose allocation and availability in latex cells. Comparing the d3 and d4 frequencies tapping, it seems that, even, the cumulated yield in d4 is lower than in d3, unless for the d4 frequency with 12 stimulations per year, there is a correlation between sucrose content and the number of annual stimulation (Gohet et al., 2003, Lacote et al 2010). In this trial, for IRCA 230, in d3 frequency, 7 stimulations per year seem to be giving the highest yield but inducing the lowest sucrose content as a signal of activated biosynthesis in latex cells (Jacob et al., 1989, d'Auzac et al;, 1997). For d4 frequency the highest number of stimulation induced one of the lowest sucrose content while the yield was one of the highest too.
The lowest girth rate was shown with the highest yielding g/t/t treatment in d4 frequency compared to d3 frequency. As it was shown by Gohet et al., 1996 and 2003 and Lacote et al, 2010, higher the yields - lower the girth rate. This shows the competition for carbohydrates between long term girth rate and yield at each tapping. This results show the effect of stimulation frequency and intensity on yield potential linked to carbon allocation (sucrose).

For clone IRCA 230 it is possible to reduce the tapping frequency from d3 to d4 while compensating that reduction by using more adapted ethephon stimulation. As the reduction of the tapping frequency induced an increase of the yield at each tapping, it must be care about the sucrose availability in the latex cells to try to still improve the possibility to adapt such reduced latex harvesting systems to the local conditions of production: bio-physic environment (climate, soils context), economic environment (labor cost, rubber price).

Acknowledgement
This study was supported by the Cambodian Rubber Research Institute. Thanks are due to director, Mr Mak Sopearvasna, specialists, and assistants.

REFERENCES

Gohet, E., Prévot, J.C., Eschbach, J.M., Clément, A., and Jacob, J.L. (1995) Hevea latex production: relationship with tree growth, influence of clonal origin and ethrel stimulation. *Proceedings of the International Rubber research and Development Board Symposium on Physiology and Molecular Aspects of Breeding of Hevea brasiliensis, 1995, Penang, Malaysia*, 200-210.

Gohet, E., Prévôt, J.C., Eschbach, J.M., Clément, A., Jacob, J.L. (1996) Clone, growth and stimulation: latex production factors. *Plantation Recherche Développement*, (3), 30-38.

Gohet, E., Lacote, R., Obouayeba, S., and Commere, J. (1991). Tapping systems recommended in West Africa. *Proceedings RRIM Rubber Growers' Conference 1991*, 235-254.

Gohet E., Chantuma P., Lacote R., Obouayeba S., Dian K., Clement-Demange A., Kurnia D. and Eschbach J.M. (2003) Latex clonal typology of *Heva brasiliensis*: physiological modelling of yield potential and clonal response to ethephon stimulation *In*: *Proceedings International Rubber Workshop on Exploitation Physiology, Kottayam, India, 2003,, 199-217,*

Jacob J.L., Eschbach J.M., Prévôt J.C., Roussel D., Lacote R., Chrestin H., d'Auzac J. (1985) Physiological basis for latex diagnosis of functioning of the laticiferous system in rubber trees. *In*: *Proceedings International Rubber Conference, Kuala Lumpur, 1985, (5), 43-65*, Rajarao J.C. and Amin L.L. eds., Kuala Lumpur, Malaysia, Rubber Research Institute of Malaya.

Jacob J.L., Serres E;, Prévôt J.C., Lacote R;, Vidal A., Eschbach J.M. and d'Auzac J. (1988) Development of *Heva* Latex Diagnosis. *Agritrop*, (12), 97-115

Jacob, J.L., Prévôt, J.C., Roussel, D., Lacote, R., Serres, E., d'Auzac, J., Eschbach, J.M., and Omont, H. (1989). Yield-limiting factors, latex physiological parameters, latex diagnosis, and clonal typology. *In "Physiology of Rubber Tree Latex" (J. d'Auzac, J.-L. Jacob and H. Chrestin, eds.)*, 345-403. CRC Press Inc, Boca Raton, Florida.

Jacob., Prévôt J.C., Lacote R., Eschbach J.M. (1995) Le diagnostic latex. *Plantations, recherche, développement*, 2 (2) 34-37.

Lukman, H.J.G, (1995) To increase the yield of small holder rubber by application of appropriate exploitation system. *Indonesian Journal of Natural Rubber Research*, 13, (3), 208-211.

Lacote R., Gabla O.R., Obouayeba S., Eschbach J.M., Rivano F., Dian K., Gohet E. 2010. Long-term effect of ethylene stimulation on the yield of rubber trees is linked to latex cell biochemistry. *Field crops research*, 115 (*1*) : 94-98).

R. Lacote, A. Doumbia, P. Thaler, S. Obouayeba and E. Gohet 2014 Advanced knowledge in latex harvest techniques: relationships between tapping intensity and latex yield. *In, IRRDB Workshop on Agronomy (Dawei) and Plant Breeding (Yangon)* 24th – 30th September 2014, Myanmar

Nugawela, A., Peries, M.R.C., Wijesekera, S. and Samarasekera, R.K., (2000) Evaluation of d/3 tapping with stimulation to alleviate problems related to d/2 tapping of Hevea. *Journal of the Rubber Research Institute of Sri Lanka*, 83, 49-61.

Obouayeba, S. and Boa D (1993). Fréquence et repos annuel de saignée d'Hevea brasiliensis, clone PB 235, dans le sud-est de la Côte d'Ivoire. Cahiers Agricultures, 2, 387-393.

Obouayeba S., Soumahin E.F., Dobo M., Lacote R., Gabla O.R., Doumbia A. 2009. Agronomic performance of the clone IRCA 111 of hevea brasiliensis under different frequencies of tapping and stimulation in South-West Côte d'Ivoire. *Journal of rubber research*, 12 (*2*) : 93-102.,

Obouayeba S., Soumahin E., Okoma K., Boko A., Dick K., Lacote R. 2012 relationship between tapping intensity and tapping panel dryness of some clones of hevea brasiliensis in Southwstern Côte d'Ivoire. *Agriculture and Biology Journal of North America*, ISSN Print: 2151-7517, ISSN Online: 2151-7525).

Paardekooper E.C., Langlois J.C., Soomark S. (1975) Influence of tapping intensity and stimulation on yield, girth and latex constitution. *In: Proc. Int. Rubb. Conf., Rubber Research Institute of Malaysia, Kual Lumpur, Malaya*, 1975, 290-296.

Paardekooper, E. C., (1989) Exploitation of the rubber tree. In: *"C.C. Webster, and W.J. Baulkwill (eds.), Rubber Longman"*, 349-414.

Rajagopal, R., Vijayakumar, K.R., Thomas, K.U. and karunaichamy, K. (2004) Effect of judicious ethephon application on yield response of Hevea brasiliensis (clone RRII 105) under 1/2S d/3 6d/7 tapping system. *Journal of Rubber Research*, 2, (2), 138-147.

Serres, E., Clément, A., Prévôt, J. C., Jacob, J. L., Commère, J., Lacote, R., and Eschbach, J. M. (1988). Clonal typology of laticiferous producing vessels in Hevea brasiliensis. *In CR. Int. Rubb. Res. Dev. Board, Expl. Physiol Amél. Hevea*. J.L. Jacob and J.C. Prévôt, ed., IRCA-CIRAD, Montpellier, 231-246.

Sopheaveasna M., (2003 General exploitation in Cambodia. In: Proceedings International Rubber Workshop on Exploitation Physiology, Kottayam, India, 2003,, 158-166, Vijayakumar K.R., Thomas K.U., Rajagopal R., Karunaichamy K. eds., Kottayam, India, Rubber Research Institute of India.

Soumahin, E.F, Kouakou, H.T, Coulibaly, L. F, Traore, S. M, Alle, J. Y, Obouayeba, S. (2012) impact of the reduction of the tapping frequency on the agronomic and physiology parameters of clone PB260 of hevea brasiliensisin the centre west of cote d'ivoire in order tmake up for the shortage of tapping labour.

Sivakumaran, and Chong, K., (1994) Yield stimulation in rubber: current status and improvements for enhanced productivity. *Proceedings of the International Planters Conference, 1994, Malaysia*, 369-408.

Thanh D.K., Sivakumaran,S. and Wong, K.C. (1996) Long term effect of tapping and stimulation frequency on yield performance of rubber cloen GT 1. *Journal of Natural Rubber Research*, 11, (2), 96-107.

Thanh, D.K., Sivakumaran, S. andWong, K.C. (1998) Influence of judicious methods of stimulation on the long term yield responses of rubber clone RRIM 600. *Proceeding of the International Rubber Research and Development Board Symposium of Natural Rubber (Hevea brasiliensis), (2), Physiology and Exploitation and Crop Protection and Planting Methods, 1997, Hochiminh City, Vietnam*, 66-70.

Vijayakumar, K.R., Thomas, K.U., and Rajagopal, R., (2000) Tapping: *In; natural rubber, Agromanagement and Crop Processing. Eds. Georges, P.J. and Jacob, K.C. Rubber Research Institute of India, Kottayam, India*, 215-238.

Vijayakumar, K.R., Thomas, K.U., Rajagopal, R and Karunaichamy, K., (2001) Low frequency tapping systems for reductions in cost of production of natural rubber. *Planters' Chronicle*, 97, (11), 451-454.